1. Introduction

Reducing the threat of the proliferation of nuclear weapons is one of the foremost goals of the United States. Proper management of spent nuclear fuel from foreign research reactors is essential to the efforts aimed at achieving these goals since much of this fuel contains highly-enriched uranium[1] (HEU), which can be directly used in simple nuclear weapons.

The concern over appropriate management of foreign research reactor spent nuclear fuel was reiterated in the Presidential Directive on Nonproliferation and Export Controls, issued by President Clinton on September 27, 1993. In particular, the Presidential Directive included the following language: "We will also seek to minimize the use of highly-enriched uranium in civil nuclear programs. To this end, the Secretary of Energy will review the need for programs to develop alternative fuels for research reactors and accelerate steps towards implementation of a policy of taking back U.S.-origin spent fuels from foreign research reactors."

1.1 Policy Background

Since 1945, every U.S. Administration has recognized that preventing the further spread of nuclear weapons must be a fundamental national security and foreign policy objective of the United States. The initial U.S. approach to nuclear technology was to classify all nuclear activities. However, the United States soon realized that it would be impossible to prevent other nations from acquiring nuclear technology.

Consequently, since the 1950's, beginning with the "Atoms for Peace" program, the United States has provided peaceful nuclear technology to foreign nations in exchange for their promise to forego development of nuclear weapons. In addition, the United States requires that any nuclear technology provided shall be subject to international safeguards and inspections to prevent diversion of materials or technology to nuclear weapons activities.

The Atomic Energy Act of 1946 was the first U.S. legislation regulating nuclear activities. The Act prohibited international nuclear cooperation until effective international safeguards were in place to prevent such cooperation from assisting in the development of foreign nuclear weapons programs. A major revision of the Atomic Energy Act in 1954 provided that foreign countries receiving nuclear assistance had to accept conditions on its use, including making a pledge not to use nuclear materials or equipment provided by the United States for military purposes.

Simply put, peaceful nuclear cooperation, under international safeguards, has been a critical component of U.S. nuclear weapons nonproliferation policy since the beginning of the atomic age. The intent of such peaceful nuclear cooperation is to prevent the development of nuclear weapons programs worldwide.

A major element of the "Atoms for Peace" program for peaceful nuclear cooperation, particularly in the early years, was the provision of research reactor technology and the HEU necessary to fuel the research reactors. Research reactors play a vital role in important medical, agricultural, and industrial applications,

[1] *Uranium enriched to 20 percent or greater in isotope 235 is known as HEU.*

and also provide a tool for fundamental scientific research. For example, research reactors are a vital tool in cancer therapy and radioimmunoassay blood testing. There are approximately 30,000 medical procedures per day in North America, 8,000 to 10,000 procedures per day in Europe, and 8,000 to 10,000 procedures per day on other continents using medical isotopes produced in research reactors in other countries. Neutron radiography provided by research reactors has enabled researchers to diagnose defects in metals and engines of many varieties and to conduct research on new materials, computer chips, and chemicals. Radioisotopes produced in research reactors have been used in leak detection in industrial components and equipment, aluminum production, and semiconductor and solar panel research. Neutron scattering experiments done in research reactors have provided insight into the biostructure of organic substances and have advanced the development of magnetic and superconducting materials. Research reactors have also been used in the environmental sciences to study waste migration, mine drainage, diffusion and transport of pollutants, water chemistry, sediment transport, atmospheric dispersion, and toxic waste management. Another important use of research reactors is irradiation testing of materials and fuel forms, including safety experimentation, to support advanced fuel design and waste management development for use in the power industry. Research reactors also have served as major training facilities in nuclear technology. For example, the research reactor operating in Austria is used by the International Atomic Energy Agency to train personnel who conduct international inspections of weapons and civil nuclear facilities worldwide.

The transfer of enriched uranium from the United States to other nations under the "Atoms for Peace" program was usually supported by a bilateral research agreement for each foreign research reactor. Before 1964, these agreements provided for the lease of the enriched uranium, with explicit provision for the return of the spent nuclear fuel to the United States. After 1964, most agreements provided for the sale of this material to the foreign nation.

After its use (irradiation) in a research reactor, the used (spent) fuel was generally returned to the United States where it was reprocessed to extract the uranium still remaining in the spent fuel. In this way, the United States maintained control over the HEU, which otherwise could be used in the production of nuclear weapons. The United States began accepting HEU spent nuclear fuel from foreign research reactors in 1958.

After 1964, the operative policy under which the United States accepted foreign research reactor spent nuclear fuel containing uranium enriched in the United States became known as the "Off-Site Fuels Policy." This policy was implemented through a series of *Federal Register* Notices issued until 1987, and was incorporated into bilateral international agreements with recipient countries. The term "Off-Site Fuels Policy" was used to indicate that the spent nuclear fuel had been irradiated at facilities not owned by the Department of Energy (DOE). Under the "Off-Site Fuels Policy," the United States accepted, temporarily stored, and reprocessed spent nuclear fuel containing HEU enriched in the United States. The rationale for the policy was to discourage the stockpiling abroad of spent nuclear fuel containing HEU and to recover the fuel value of the HEU remaining in the spent nuclear fuel.

In response to increasing congressional and public concern about the potential diversion of HEU for use in nuclear weapons by foreign nations, subnational groups, or terrorist organizations, DOE in 1978 initiated the Reduced Enrichment for Research and Test Reactors (RERTR) program. The RERTR program was aimed at reducing the use of HEU in civilian programs by promoting the conversion of foreign research reactors from HEU fuel to low enriched uranium (LEU) fuel. Research reactors are of particular interest in this endeavor because the major civilian use of HEU is as fuel in nuclear research reactors.

As a part of the RERTR program, DOE developed LEU fuel and worked with foreign research reactor operators to modify their reactors to run on such fuel. The foreign research reactor operators who converted to LEU fuel did so in support of nuclear weapons nonproliferation objectives, even though such conversions were expensive and generally resulted in reductions in the capabilities of the reactors and increased operating costs.

From the beginning of the RERTR program, foreign research reactor operators made it clear that their willingness to convert their research reactors to LEU fuel was contingent upon the continued acceptance by DOE of their spent nuclear fuel for disposition in the United States. In 1986, to further encourage foreign research reactor operators to convert to LEU fuel, the DOE "Off-Site Fuels Policy" was extended to include the acceptance of spent nuclear fuel containing LEU enriched in the United States.

The RERTR program has been highly successful and many foreign research reactors have been modified to operate, or have been designed to operate, with the high-density LEU fuels developed by the RERTR program, instead of HEU fuel. Of the 42 foreign research reactors with power levels equal to or above one million watts that use U.S. enriched fuel, 37 could operate with the currently available high-density LEU fuels. Of these, 25 are either operating on LEU fuel, or have ordered LEU fuel, and DOE anticipates that an additional eight reactors will convert to LEU fuel by 2001. Work is underway to develop improved high-density LEU fuels that would enable the remaining HEU fueled reactors to convert as well. Thus, the RERTR program has contributed to a significant reduction in the use of HEU in foreign research reactors.

The RERTR program is also developing the technology necessary to substitute LEU for the HEU in targets that are currently irradiated in reactors to produce the radioisotope molybdenum-99 for use as a diagnostic tool in nuclear medicine. The current limited nuclear commerce in HEU for medical targets can be reduced and eventually eliminated when LEU targets become available. When combined, these RERTR program activities can virtually eliminate the need for civilian commerce in HEU.

In 1988, DOE's "Off-Site Fuels Policy" to accept HEU spent nuclear fuel expired. At the end of 1992, the policy as it applied to the acceptance of LEU spent nuclear fuel also expired. The "Off-Site Fuels Policy" was not immediately renewed because of the need to assess the environmental impacts of a new policy. Because the United States has not been in a position to accept HEU fuel for 6 years [except for two recent "urgent relief" shipments of 252 spent nuclear fuel elements, 153 of which were from Denmark, Austria, Sweden, and the The Netherlands, with the remaining 99 elements from Switzerland and Greece, conducted under DOE's "Environmental Assessment of Urgent-Relief Acceptance of Foreign Research Reactor Spent Nuclear Fuel" (DOE, 1994m)], many foreign research reactor operators will soon run out of storage capacity or face safety and regulatory issues associated with the presence of spent nuclear fuel at their sites.

Although those foreign research reactors who could obtain regulatory clearance to build new storage capacity could do so within the duration of the proposed policy, they do not have time to do so in the near term before they run out of space. Storage of the spent nuclear fuel is a concern because it contains both enriched uranium (some of it highly-enriched material suitable for use in nuclear weapons) and highly radioactive waste products. The storage of such spent nuclear fuel must be accomplished with considerable care to ensure that the spent nuclear fuel does not corrode. If it does corrode, it could release fission products within the storage facility (making action to protect the spent nuclear fuel from further degradation difficult). In the extreme, uranium could be released from the spent nuclear fuel and settle to the bottom of the storage facility, creating the potential for a chain reaction.

Even if the spent nuclear fuel is kept in pristine condition (a relatively straightforward task given the resources and determination to store it correctly), the accumulation of large quantities of spent nuclear fuel containing HEU raises the possibility that some of the spent nuclear fuel might be stolen and its uranium diverted into a nuclear weapons program. In addition, spent nuclear fuel storage is an expensive undertaking (partially so because of the steps needed to avoid the problems outlined above) and is limited by local regulation in many countries. As a result, the cessation of the U.S. acceptance of foreign research reactor spent nuclear fuel associated with the expiration of the "Off-Site Fuels Policy" has created significant problems for the research reactor operators and has undercut the perceived reliability of the United States as a partner in peaceful nuclear cooperation, a cornerstone of U.S. nuclear weapons nonproliferation commitments enshrined in the *Treaty on the Non-Proliferation of Nuclear Weapons.*

With respect to the broader role that the United States plays in worldwide peaceful nuclear cooperation, President Reagan warned as early as July 1981, that "if we are not such a partner, other countries will tend to go their own ways and our influence will diminish. This would reduce our effectiveness in gaining the support we need to deal with proliferation problems." (Statement on the U.S. Nuclear Nonproliferation Policy, July 16, 1981.) More recent correspondence from the United States National Security Council, Department of State, Department of Defense, and the Nuclear Regulatory Commission (NRC) underscores the importance and urgency of support for the RERTR program objectives and the need for immediate action to reduce the use of HEU in civil programs. For example, in a recent letter to Secretary of Energy Hazel R. O'Leary, Secretary of State Warren Christopher stated, "The spent fuel acceptance policy which the EIS supports is central to our goal of preventing the spread of nuclear weapons -- and therefore to a major national security objective of this administration" (see Appendix G).

If the United States does not accept the foreign research reactor spent nuclear fuel, some of the foreign research reactors may be forced to shut down, as they will have no way to store any additional spent nuclear fuel. Other research reactor operators may have the option of reprocessing[2] their spent nuclear fuel (separating the uranium from the fission products for use as new fuel) at existing facilities. British and/or French reprocessing plants might accept foreign research reactor spent nuclear fuel for reprocessing, but have done so in the past only on the condition that the reprocessing customer agrees to take back the reprocessing wastes. Some of the countries in which the foreign research reactors are located do not have a domestic waste repository or other facilities for storing the highly-radioactive wastes generated from reprocessing for the near term. Other countries will not allow reprocessing because they object to reprocessing on environmental or nuclear weapons nonproliferation grounds.

While the U.S. Government has full confidence in the physical protection and safeguards systems in place at the British and French reprocessing facilities, reprocessing of spent nuclear fuel containing HEU, as it has been done in the past, would sustain international commerce in HEU, in direct contradiction to the U.S. position on nuclear weapons nonproliferation. It would likely mean that the research reactors pursuing this option would continue operations on the HEU fuel cycle because currently they have a method of disposing of HEU spent nuclear fuel, but not LEU spent nuclear fuel. Neither Dounreay (the British reprocessing facility in Scotland), Marcoule in France, nor any other available facility is currently accepting or has the special equipment that would be used in the United States to reprocess the high density LEU fuels that the United States is encouraging foreign research reactors to use to replace the

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2 *Reprocessing refers to the disassembly of spent nuclear fuel (usually by dissolving it in acid) to allow the uranium, and possibly other fissile materials, to be separated from the fission products and structural parts of the spent nuclear fuel. The fissile materials can then be reused, and the fission products are discharged as waste. These wastes are dissolved in specially formulated molten glass and cast into stainless steel cylinders (or in some cases, in foreign countries, may be mixed with special concretes and poured into steel drums) prior to disposal.*

HEU fuels. Hence, if the research reactors decide to use reprocessing as it has been managed up to this point to prevent backlogs of spent nuclear fuel from building up, they would have to continue to use HEU fuels. This could result in reactor operators delaying or canceling plans to convert to LEU, or in some cases, withdrawing from the RERTR program and reconverting from LEU to HEU fuels. The United Kingdom Atomic Energy Authority is considering adding an LEU processing capability to its plant in Dounreay. At this time, it is not clear that this plant will continue to operate. If the Dounreay facility continues to operate and if an LEU reprocessing capability is installed, that would mean that Dounreay customers could operate their research reactors on LEU.

If some foreign research reactor operators were to withdraw from the RERTR program and rely instead on HEU fuels, with attendant lower costs and enhanced performance, other research reactor operators would be under pressure to convert to the use of HEU for competitive reasons. Since the United States, under the Energy Policy Act of 1992, is barred from exporting HEU to virtually all foreign research reactors, research reactor operators seeking continued use of HEU would be forced to seek alternate suppliers. Russia and China are sources of HEU; and, should they choose to provide a ready supply of HEU, many foreign research reactor operators would be forced to consider abandoning the RERTR program and reconverting to HEU. In addition, the United States is currently attempting to convince Russia and China to implement programs similar to the United States' RERTR program to encourage their nuclear fuel customers to phase out use of HEU in their research reactors. However, if the United States cannot convince those countries to which it has exported nuclear fuel to stop using HEU, the United States would stand little chance of convincing Russia and China to do so with the countries to which they export nuclear fuel.

Additionally, several developed countries involved in the RERTR program are exporters of research reactors. In recent years, they have required that reactors exported to other countries be fueled with LEU. However, if foreign research reactor operators begin delaying or canceling plans to convert to LEU, and thereby continue to use HEU, foreign research reactor purchasers would demand HEU-fueled reactors. This could lead to renewed international commerce in weapons-usable HEU, and would be antithetical to the policy goal of seeking to minimize and eventually eliminate the civil use of HEU.

Another crucial consideration in proposing to accept spent nuclear fuel shipments from foreign research reactors is the *Treaty on the Non-Proliferation of Nuclear Weapons*. The Non-Proliferation Treaty is the basis for the world's nuclear weapons nonproliferation regime. The purpose of the Non-Proliferation Treaty is to keep the number of countries with nuclear weapons from growing. Five countries acknowledge having nuclear weapons: the United States, Russia, the United Kingdom, France, and China. In addition to the five acknowledged nuclear weapons States, 175 other nonnuclear weapons States are members of the treaty. The obligations for compliance with the Non-Proliferation Treaty apply to both nuclear weapons States and nonnuclear weapons States. While nonnuclear weapons States agree not to pursue development or acquisition of nuclear weapons or other nuclear explosive devices, the nuclear weapons States commit to the eventual elimination of their nuclear weapons arsenals and to assist nonnuclear weapons States with peaceful applications of nuclear energy. The Off-Site Fuels Policy and RERTR program are examples of how the United States has helped other nations with peaceful applications of nuclear energy in the past.

The parties to the Non-Proliferation Treaty met in May of 1995 and agreed by consensus to extend the treaty indefinitely and without conditions. Making this vital treaty a permanent part of the international nonproliferation regime was an important U.S. foreign policy achievement. One key to the success of the 1995 Non-Proliferation Treaty Conference was the ability of the United States to convince other

Non-Proliferation Treaty parties that the nuclear weapons States were in compliance with their obligations under Article IV of the Non-Proliferation Treaty to assist the nonnuclear weapons States with applications of nuclear energy for peaceful purposes.

Although the Non-Proliferation Treaty was extended indefinitely at the 1995 Non-Proliferation Treaty Conference, the parties also agreed to review the treaty every five years to ensure that all parties are in compliance. Any country which has been compelled to shut down its research reactors, or has been forced to seek reprocessing, could accuse the United States of not having fulfilled its treaty obligations. This accusation, however ill-founded, could be made not only by the affected countries, but by any country opposed to the interests of the United States.

In the past, some individuals and groups have incorrectly asserted that the U.S. concerns with reprocessing of HEU spent nuclear fuel discussed above are inconsistent with the U.S. policy of continuing to grant prior consent[3] to Japan and Western European nations for reprocessing of power reactor spent nuclear fuel. The U.S. Government believes that the growing quantities of plutonium in international commerce do present a threat to the efforts of the United States and other countries to prevent the proliferation of nuclear weapons. In countries where material control and accounting or physical protection systems are not sufficiently rigorous, there is a risk of diversion or theft of such materials. In addition, even in countries with effective nuclear weapons nonproliferation commitments, the presence of unneeded stocks of plutonium could raise security concerns on the part of neighboring countries. Accordingly, the U.S. Government does not encourage the civil use of plutonium. Nevertheless, the United States is also committed to being a reliable nuclear trading partner and to avoiding interference in peaceful nuclear programs. Therefore, in Western Europe and Japan where there are well-established civil reprocessing and plutonium facilities and comprehensive nuclear weapons nonproliferation commitments, the United States will continue, in appropriate instances, to grant prior consent for reprocessing of plutonium-bearing spent fuels on a predictable and long-term basis. Undertaking the use of U.S. consent rights to block reprocessing would lead to confrontation with, and would jeopardize the support from, nations that are in accord with the broader U.S. nuclear weapons nonproliferation goals and agenda.

1.2 Purpose and Need For Agency Action

Curbing the spread of nuclear weapons has been an important foreign policy and national security objective of the United States for nearly half a century. The proposed action is one action among many being pursued by the United States to reduce the potential for the proliferation of nuclear weapons. More specifically, the proposed action is intended to support the U.S. policy objective of seeking to reduce, and eventually to eliminate, HEU from civil commerce.

The nuclear weapons proliferation concerns addressed by the proposed action stem from the use of HEU as fuel for foreign research reactors and the presence of large residual amounts of HEU in the spent nuclear fuel from these research reactors. HEU can be used directly in simple nuclear weapons. In the past, the United States has encouraged reductions in the use of HEU as research reactor fuel by conducting

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[3] *In general terms, the Atomic Energy Act of 1954, as amended, requires that before the United States may export nuclear material (e.g., enriched uranium), nuclear equipment, or sensitive nuclear technology to another country, that country must agree to obtain the consent (i.e., approval) of the United States before it may transfer that material, equipment, or technology to another country. However, in its 1988 agreement for cooperation with Japan, the United States has granted "prior consent" (i.e., approval in advance) for Japan to transfer power reactor spent fuel to France for reprocessing for the life of the agreement (the initial term is 30 years), subject to certain conditions relating to Japan's nuclear weapons nonproliferation activities. The U.S. Government has made a commitment to include a similar arrangement in new agreements that it is currently negotiating with Euratom and Switzerland.*

the RERTR program (to develop high-density LEU fuels to replace the HEU fuels). The United States also previously prevented the development of foreign stockpiles of HEU in foreign research reactor spent nuclear fuel by conducting the "Off-Site Fuels Policy" (i.e., by accepting the spent nuclear fuel into the United States and reprocessing it).

To illustrate the level of concern that exists regarding the proposed action, DOE has received letters from the U.S. Department of State, the Nuclear Regulatory Commission, the Arms Control and Disarmament Agency, the International Atomic Energy Agency, and the foreign research reactor operators, all urging DOE to resume acceptance and management of foreign research reactor spent nuclear fuel. Failure to manage this spent nuclear fuel would encourage international commerce in HEU.

HEU fuel in research reactors is more of a proliferation concern than the plutonium in these reactors for three reasons.

First, it is much easier to fashion a simple nuclear weapon out of HEU than plutonium. The chemical separation of HEU metal from HEU spent nuclear fuel would be simpler than the chemical separation of plutonium metal from LEU spent nuclear fuel. HEU is also less radioactive than plutonium, so it presents less of a health hazard to the people working with it. Furthermore, pure plutonium metal is extremely pyrophoric; that is, small chips of pure plutonium metal can ignite spontaneously unless the metal is handled very carefully in special facilities. All these problems with plutonium make HEU fuel a more attractive target for diversion into a nuclear weapons program.

Second, the amount of HEU that would be removed from current civil commerce under the proposed action is much greater than the amount of plutonium that would be produced in replacement LEU fuel elements in the same reactors. The proposed action involves the removal of approximately 4.6 metric tons (5.1 tons) of HEU. For comparison, the plutonium that would be produced in the replacement LEU nuclear fuel is so dilute that even if all the plutonium were somehow extracted, only about 120 kg (265 lb) of plutonium would be produced. This reduction in the amount of weapons grade material in circulation in the future would significantly reduce the threat of nuclear proliferation.

Third regarding fresh (not spent) nuclear fuel containing HEU, this nuclear material would be ideal for diversion into a nuclear weapons program because it would not require chemical separation as spent nuclear fuel would. In the absence of a policy to eliminate HEU from civil commerce, fresh HEU fuel would be shipped to the foreign research reactors from foreign suppliers such as Russia or China. Such shipments would present an additional proliferation risk that would not exist if research reactors worldwide operate on the LEU fuel cycle.

If the United States takes no action to accept foreign research reactor spent nuclear fuel, or otherwise eliminate much of the HEU it contains (e.g., by blending it with natural or depleted uranium to make LEU), one or more of the following events is almost certain to occur. First, some of the foreign research reactors would simply shut down. This does not solve the concerns regarding foreign research reactor spent nuclear fuel, however, since the countries whose reactors were forced to shut down could argue, rightly or wrongly, that the United States was not living up to its obligations under the *Treaty on the Non-Proliferation of Nuclear Weapons* to assist nonnuclear weapons States in the peaceful application of nuclear energy. In addition, the spent nuclear fuel already discharged by the foreign research reactors would still be in storage at the reactor sites. For about 70 percent of the foreign research reactors, this spent nuclear fuel would contain HEU that could be diverted into the production of nuclear weapons if it were removed from the spent nuclear fuel.

Second, some of the foreign research reactors might continue operating and allow their inventory of spent nuclear fuel to build up, much of it containing HEU. The United States could, theoretically, assist such countries (and those with shutdown reactors still holding spent nuclear fuel) in building modern, diversion-resistant spent nuclear fuel storage facilities. This could be extremely expensive, as there are approximately 104 research reactors located in 41 foreign countries. Furthermore, even if perfectly secure storage facilities were built, all that would be required to frustrate their function would be a coup or other change in government leaving a regime in power that is unconcerned about the proliferation of nuclear weapons. Then the spent nuclear fuel could be diverted into a weapons production program, despite the storage assistance that had been provided by the United States. It seems clear that the potential for such an event to occur would increase with the number of spent nuclear fuel stockpiles that are allowed to build up around the world and the length of time they exist.

Finally, some foreign research reactors would be likely to reprocess their spent nuclear fuel. Much of the U.S.-origin enriched uranium was exported under agreements that require prior consent by the United States before the spent nuclear fuel can be shipped to another country, as would be required for almost all reprocessing of foreign research reactor spent nuclear fuel containing uranium enriched in the United States. However, approximately 50 percent of the foreign research reactor spent nuclear fuel is located in countries where such prior consent is not required. The current practice of the most likely reprocessing plant (i.e., the facility in Dounreay, Scotland) is to allow the customer (i.e., the foreign research reactor operator) to specify the form of the separated uranium and its disposition. Thus, the foreign research reactor operator could specify that any separated HEU should be returned as HEU. Furthermore, neither Dounreay nor any other reprocessing facility currently accepts or has the capability to reprocess the high-density LEU fuels that the United States is encouraging foreign research reactors to use to replace the HEU fuels. Thus, in the absence of action to resolve the questions of the disposition of spent nuclear fuel, outlined above, any foreign research reactor operator that reprocesses to control the inventory of spent nuclear fuel must continue to use, or convert back to, fuel containing HEU. Reprocessing under these circumstances leads to perpetuation of the HEU fuel cycle.

While there is some danger of diversion of the HEU in the spent nuclear fuel while it is in storage, the threat is relatively low since the uranium is an integral part of the solid metal spent nuclear fuel elements and is mixed with highly radioactive fission products. A sophisticated chemical processing plant would be required to separate the uranium and convert it into a form suitable for use in a nuclear weapon. However, once the uranium has been separated from the spent nuclear fuel in a reprocessing plant, the situation is fundamentally changed. Any HEU separated in a reprocessing plant would be readily usable for nuclear weapons production, essentially the same as fresh HEU that has never been in a reactor. Therefore, despite U.S. confidence in the capability and determination of the United Kingdom and France to properly safeguard any separated HEU in their reprocessing plants, once the uranium leaves their facilities, the potential for illegal diversion of the material during transit or in the country of destination increases markedly. The rate of increase for potential diversion depends both on the countries and international waterways through which the material must be shipped, the country of final destination, and the number and size of the shipments being made.

Although it is unlikely that all the HEU that has been exported can be recovered or blended down to LEU through the proposed action, it is in the best interest of the United States to make every effort to ensure the proper management of the largest fraction of this material. Arrangements would have to be worked out with foreign reprocessors that would be supportive of U.S. nuclear weapons nonproliferation objectives to minimize the civil use of HEU worldwide.

By proposing a policy for management of certain foreign research reactor spent nuclear fuel, DOE and the Department of State do not seek to indefinitely accept or otherwise manage spent nuclear fuel from foreign research reactors. Rather, the purpose of the proposed new policy is to remove as much U.S.-origin HEU as possible from international commerce while giving the foreign research reactors and their host countries time to convert to operation with LEU fuel and make their own arrangements for disposition of subsequently generated LEU spent nuclear fuel. The foreign research reactor operators and countries in which the research reactors are operating must be prepared to implement their own arrangements for disposition of their spent nuclear fuel after the policy expires.

1.3 Scope of the Environmental Impact Statement (EIS)

This EIS evaluates the potential environmental impacts that could result from the DOE and Department of State joint proposal to adopt a policy to manage spent nuclear fuel from foreign research reactors. Only spent nuclear fuel containing uranium enriched in the United States would be covered by the proposed policy. The purpose of the proposed policy is to promote U.S. nuclear weapons nonproliferation policy objectives, specifically by seeking to reduce, and ultimately eliminating, HEU from civilian commerce. This EIS identifies and evaluates the potential environmental impacts of management alternatives to the proposed action. Implementation of Management Alternative 1 to the proposed action could include the receipt of foreign research reactor spent nuclear fuel at one or more U.S. marine ports of entry, overland transport to one or more DOE sites, and management (interim storage and ultimate disposition) in the United States. DOE will also analyze near-term chemical separation as an alternative to storing the intact spent nuclear fuel pending ultimate disposition.

Under Management Alternative 1 to the proposed action, DOE would accept or otherwise manage spent nuclear fuel containing HEU and LEU from 41 foreign nations, if such spent nuclear fuel is already discharged[4] or would be discharged within the 10-year policy period. Figure 1-1 displays the geographic locations of these nations. The United States would bear the full cost for the management of the foreign research reactor spent nuclear fuel from developing nations.[5] For developed nations, however, the United States would charge a fee for spent nuclear fuel management activities conducted by the United States.[6]

DOE recognizes that Figure 1-1 lists nations that would currently not be considered to be nuclear weapons proliferation risks. History indicates that the United States cannot predict today, with assurance, which countries may develop into proliferation risks in the future. On the other hand, there are good reasons for accepting spent nuclear fuel from nations that are in accord with U.S. nuclear nonproliferation goals, and that have stable governments and excellent nonproliferation credentials. First, several of these countries manufacture research reactors for sale to third world countries. If the United States refuses to help these countries with the management of the spent nuclear fuel from their research reactors, several of their reactors are likely to convert to use of HEU for fuel. If that occurs, their customers in the third world countries would probably also demand to be supplied with reactors fueled with HEU.

Second, both the Soviet Union and China also exported research reactors in the past. The United States is currently engaged in discussions to convince Russia (as the successor supplier to the Soviet Union's allies) and China to work with their nuclear fuel customers to convert their research reactors from HEU to LEU.

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4 *"Discharged" refers to removal of irradiated fuel from a reactor.*

5 *Developing nations are defined by the World Development Report as having other than high-income economies (World Bank, 1994).*

6 *For purposes of determining which nations are eligible for assistance from the United States in handling their foreign research reactor spent nuclear fuel, Taiwan is considered to be in the high-income economy category.*

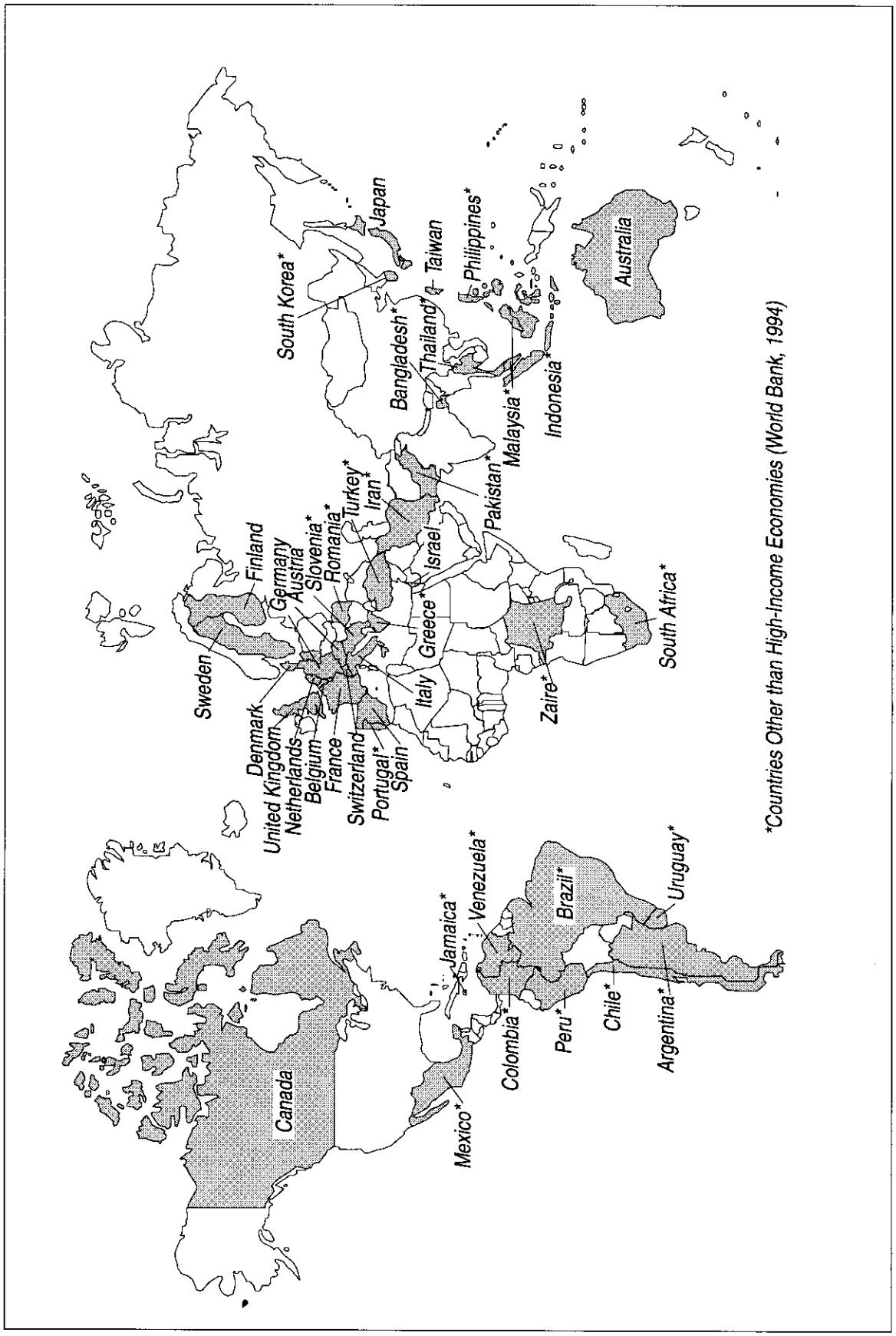

Figure 1-1 Nations with Research Reactors that are Holding or are Expected to Generate Spent Nuclear Fuel Containing Uranium Enriched in the United States

If the United States were to take action that caused its nuclear fuel customers to reconvert their research reactors to HEU, that would likely ensure the failure of U.S. efforts to get Russia and China to encourage their nuclear fuel customers to switch to LEU.

A second alternative (Management Alternative 2) for implementation of the proposed action has been identified and evaluated in this EIS. This alternative includes two subalternatives: (1) to provide assistance to foreign nations with storage of their spent nuclear fuel overseas, and (2) to provide non-technical assistance (financial and/or logistical) in the reprocessing of their spent nuclear fuel. The third alternative (Management Alternative 3) would consist of a combination of various elements of Management Alternatives 1 and 2. For example, a portion of the spent nuclear fuel could be managed overseas, and the remaining portion could be managed in the United States. A No Action Alternative is also evaluated in this EIS.

Under any of these action alternatives, no definitive proposals can be specified at this time for management of the foreign research reactor spent nuclear fuel beyond a 40-year interim management period because insufficient data are available to allow future management proposals to be defined, or for the potential environmental impacts of the final disposition of spent nuclear fuel to be evaluated. As a result, the EIS analysis for the time period beyond 40 years is qualitative rather than quantitative. The qualitative assessment includes consideration of disposal of intact foreign research reactor spent nuclear fuel, as well as disposal of vitrified high-level waste resulting from chemical separation of foreign research reactor spent nuclear fuel.

Certain potential actions discussed in this EIS will depend on decisions to be made under other National Environmental Policy Act (NEPA) analyses. Specifically, the site at which the foreign research reactor spent nuclear fuel would be managed, if accepted in the United States, will be selected based on the analyses documented in the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (Programmatic SNF&INEL Final EIS) (DOE, 1995c). An exception to this would occur if the "No Action" alternative, or any other alternative that does not include acceptance of foreign research reactor spent nuclear fuel, were selected after completion of the Programmatic SNF&INEL Final EIS. In that case, any site at which foreign research reactor spent nuclear fuel management activities might be conducted in the United States would be selected pursuant to the analyses in this EIS.

The Record of Decision for the Programmatic SNF&INEL Final EIS (DOE, 1995c) was issued on May 30, 1995. In accordance with this Record of Decision, all of the aluminum clad foreign research reactor spent nuclear fuel accepted by DOE would be managed at the Savannah River Site in South Carolina, and any other foreign research reactor spent nuclear fuel to be accepted by DOE would be managed at the Idaho National Engineering Laboratory. This is why the Comment Response Document (Volume 3) focuses on the Savannah River Site and Idaho National Engineering Laboratory as sites where any spent fuel accepted in the United States under the proposed policy would be managed, consistent with the Programmatic SNF&INEL Final EIS Record of Decision. Nevertheless, all five of the spent nuclear fuel management sites originally considered in the Draft EIS have been kept in this Final EIS to maintain maximum consistency with the analyses provided in the Programmatic SNF&INEL EIS (DOE, 1995c and 1994m).

In this EIS, DOE and the Department of State, in consultation with other government agencies, designate the acceptance and management of foreign research reactor spent nuclear fuel and target material in the United States as the preferred alternative.

1.4 Decisions to be Made Based on this EIS

The principal policy decision for which this EIS will provide a basis is whether DOE and the Department of State should adopt a policy for the United States to manage foreign research reactor spent nuclear fuel containing U.S.-enriched uranium. A necessary part of this decision is the amount and types of foreign research reactor spent nuclear fuel to be managed under such a policy.

If a decision is made to adopt such a policy, then decisions on management implementation must also be made. This EIS is intended to provide the necessary analysis, not only for the decision on adoption of a policy, but also for decisions on management implementation of such a policy, if adopted. Should the decision be to manage the spent nuclear fuel in the United States, decisions to be made on implementation of such a policy include:

- the duration of any foreign research reactor spent nuclear fuel management policy;
- the modes of ocean and overland transport required for shipping any foreign research reactor spent nuclear fuel to be accepted into the United States;
- the ports of entry through which DOE would receive foreign research reactor spent nuclear fuel;
- the need for the construction of new facilities or modification of existing facilities to manage the foreign research reactor spent nuclear fuel to be accepted, and the design, construction, and operation of any such new or modified facilities;
- whether to use near-term chemical separation of the foreign research reactor spent nuclear fuel, as an alternative to storing intact foreign research reactor spent nuclear fuel; and
- whether to accept uranium target material that was enriched in the United States and irradiated in foreign research reactors during the production of molybdenum-99 for medical purposes (in addition to the foreign research reactor spent nuclear fuel discussed above).

1.5 Relationship of this EIS to Other NEPA Documents and Reports Relating to Spent Nuclear Fuel Management

The relationship of this EIS to other DOE NEPA reviews, either completed or currently under preparation, and other DOE analyses is discussed in this section. These reviews and analyses are:

1. *Environmental Assessment of Urgent-Relief Acceptance of Foreign Research Reactor Spent Nuclear Fuel.* This Environmental Assessment covers marine transport, receipt, overland transport, and interim wet storage in the Receiving Basin for Offsite Fuels (RBOF) at the Savannah River Site of up to 409 elements of spent nuclear fuel from foreign research reactors. The Environmental Assessment and associated Finding of No Significant Impact were issued on April 22, 1994.

   The proposed action analyzed in this Environmental Assessment was intended to ensure that the eight research reactors from which urgent-relief spent nuclear fuel shipments were proposed would continue to participate in the RERTR program (a key U.S. nuclear weapons nonproliferation program) until this EIS could be completed and a decision made on whether to adopt and implement the proposed policy to manage foreign research reactor spent nuclear fuel containing uranium enriched in the United States.

2. *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (Programmatic SNF&INEL EIS).* Volume 1 analyzes at a programmatic level the potential environmental impacts over the next 40 years of alternatives related to the transportation, receipt, processing, and storage of spent nuclear fuel under the responsibility of DOE. This EIS was prepared in compliance with the order of the U.S. District Court for the District of Idaho [*Public Service Company of Colorado v. Andrus*, Memorandum of Opinion (December 22, 1993)]. The Final EIS and the Record of Decision were published on April 28, 1995 and May 30, 1995, respectively. This EIS formed the basis for deciding, on a programmatic level, which sites will be used for the management of the various types of spent nuclear fuel to which DOE holds title. It included the amount of foreign research reactor spent nuclear fuel that might be accepted in its assessment of potential impacts, and addressed the sites at which the foreign research reactor spent nuclear fuel could be stored if a decision is made to accept foreign research reactor spent nuclear fuel. The Record of Decision indicated that aluminum clad spent fuel will be consolidated at the Savannah River Site and non-aluminum clad fuel will be managed at the Idaho National Engineering Laboratory. On October 17, 1995, litigation with the State of Idaho was settled by stipulation of the parties and entry of a Consent Order. This settlement would provide for the transportation of up to 61 shipments of foreign research reactor spent fuel to Idaho National Engineering Laboratory prior to the year 2000, if DOE and the Department of State choose to adopt a policy of accepting such foreign research reactor spent nuclear fuel. After the year 2000, additional shipments of such spent nuclear fuel could be made to Idaho National Engineering Laboratory under the stipulated settlement and Consent Order. Notwithstanding the Record of Decision, a full analysis of all five management sites considered in the Programmatic SNF&INEL Final EIS has also been included in this EIS to maintain maximum consistency with the analysis provided in the Programmatic SNF&INEL EIS.

3. *Waste Management Programmatic EIS.* The Waste Management Programmatic EIS has evolved from the formerly named Environmental Management Programmatic EIS, as was most recently described in a *Federal Register* Notice (55 FR 42633), on August 22, 1990. The Draft Waste Management Programmatic EIS was issued in August 1995 and analyzes programmatic alternatives for DOE-wide management of five waste types: high-level radioactive waste, low-level radioactive waste, low-level mixed waste, transuranic waste, and hazardous waste. DOE expects to issue the Final Waste Management Programmatic EIS in late 1996.

4. *Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and other Reactor Irradiated Nuclear Materials and their Environmental Safety and Health Vulnerabilities.* The Spent Fuel Working Group Report, dated November 1993, presents a comprehensive assessment of the conditions of spent nuclear fuel and other irradiated materials stored at DOE facilities. Eight DOE sites were identified as containing storage facilities with major vulnerabilities that need to be resolved. The vulnerabilities identified in this report have been considered in the analysis of the actions that would be involved in management of foreign research reactor spent nuclear fuel in the United States.

5. *Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities.* The Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities is a three-phased approach to remedy vulnerabilities identified in the Spent Fuel Working Group Report. The Phase-I Plan of Action, dated

February 1994, addressed 31 of 33 high-priority vulnerabilities and 48 lower-priority issues. The Phase-II Plan of Action, dated April 1994, was the product of follow-on work to the Phase-I report, and resolved a majority of the funding issues associated with spent fuel vulnerabilities. The Phase-III Plan of Action, issued in October 1994, focused on the resolution of critical policy issues and provided individual action plans that addressed all the identified vulnerabilities. In the preparation of this EIS on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel, the actions being taken to resolve these issues have been evaluated to ascertain that any existing facilities considered for use in receipt, handling, or storage of foreign research reactor spent nuclear fuel are capable of performing satisfactorily. The EIS evaluates storage capabilities and alternatives at the interim storage sites and whether potential storage sites would be capable of immediately implementing the proposed action.

6. *Interim Management of Nuclear Materials Final Environmental Impact Statement.* This EIS considers the impacts of managing nuclear materials stored at the Savannah River Site, including stabilization by separating the nuclear materials from fission and decay products in the chemical separation facilities and conversion of the resulting liquids to solids in waste and material conversion facilities, including the Defense Waste Processing Facility, the FB-, HB, and FA-Lines, and the saltstone facility. The Final EIS was issued in October 1995. A Record of Decision and Notice of Preferred Alternative was published in the *Federal Register* (60 FR 65300) on December 19, 1995. Decisions were made for the majority of materials covered by the EIS in the Record of Decision and processing Mark-16 and Mark-22 fuels and blending down the resulting HEU to LEU was identified as the preferred alternative for those materials. These fuels are similar to the aluminum-based foreign research reactor spent nuclear fuel although significant corrosion has been identified. An amended Record of Decision is expected soon regarding the Mark-16 and Mark-22 fuels. DOE has taken and will take into consideration all Records of Decision on the Interim Management of Nuclear Materials Final EIS in the preparation of this EIS and in reaching a decision on how to implement the proposed policy, if adopted.

7. *Disposition of Surplus Highly Enriched Uranium Environmental Impact Statement.* The Draft EIS, issued in October 1995, assesses the environmental impacts of alternatives for the disposition of U.S.-origin HEU that has or may be declared surplus to national defense and defense-related program needs, in order to eliminate the nuclear proliferation risk and, where practical, recover economic value and peaceful, beneficial reuse of the material. Under the preferred alternative, the HEU would be blended to LEU at four sites, including the Savannah River Site; under this alternative, most of the HEU would be blended to LEU as fuel feed for commercial nuclear power plants to generate electricity, while that which cannot meet commercial fuel specifications would be blended to low level waste. The Final EIS and Record of Decision are scheduled for April and May 1996, respectively.

8. *Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement.* This EIS will assess the environmental impacts of reasonable alternatives for safe, secure and internationally-accountable long-term storage of non-surplus, U.S.-origin plutonium and HEU, long-term storage of plutonium and HEU that are not part of the strategic reserves need for weapons research and development, and post-interim storage of surplus fissile material prior to disposition. This programmatic EIS will also analyze reasonable alternative strategies and technologies for disposition of U.S.-origin plutonium that is or may be declared surplus to defense and defense-related program needs,

in order to eliminate the proliferation risk by making the material as proliferation-resistant as spent fuel. The Savannah River Site will be analyzed in conjunction with the various alternatives for both storage and disposition. The Notice of Intent to prepare a programmatic EIS was issued in June 1994 (59 FR 31985), and the scope of the EIS was revised in April 1995 (60 FR 17344). The Draft EIS is expected in early 1996, and the Final EIS and Record of Decision are expected in late 1996.

9. *Environmental Impact Statement Evaluating Container Systems for the Management of Spent Nuclear Fuel.* This EIS was originally titled *Environmental Impact Statement for a Multi-Purpose Canister System for the Management of Civilian and Naval Spent Nuclear Fuel.* This EIS, as described in 59 FR 53442 (1994), was intended to address the potential environmental impacts associated with alternative systems for storage and transport of spent nuclear fuel assemblies for civilian spent nuclear fuel. DOE decided for programmatic reasons in November 1995 to withdraw its proposal to prepare this EIS. The Department of the Navy has announced in a *Federal Register* Notice (60 FR 62829) that it will take the lead in preparing this EIS for evaluating container systems for the management of Navy spent nuclear fuel. DOE is a cooperative agency on this EIS.

10. *F-Canyon Plutonium Solutions Environmental Impact Statement.* This EIS evaluated the potential environmental impacts over the next 10 years of alternatives for stabilization of plutonium solutions currently stored in the F-Canyon at the Savannah River Site. The plutonium solutions remain from reprocessing operations that DOE suspended in 1992 at the Savannah River Site. The Record of Decision for this EIS announced that DOE would implement the preferred alternative analyzed in the EIS. This alternative is to process the plutonium solutions to plutonium metal.

11. *Defense Waste Processing Facility Supplemental Environmental Impact Statement.* This Supplemental EIS examines the cumulative environmental impacts of modifications made to the Defense Waste Processing Facility and associated high-level waste facilities at the Savannah River Site since the issuance of the 1982 EIS. The preferred alternative for the proposed action under this Supplemental EIS is to continue construction and begin operation of the Defense Waste Processing Facility as designed. The Final Supplemental EIS was completed in November 1994 and the Record of Decision was issued on April 12, 1995 (60 FR 18589). The DOE decision was to complete construction and startup testing and begin operation of the facility as currently designed. One of the Implementation Alternatives considered in the Foreign Research Reactor Spent Nuclear Fuel EIS is to chemically separate a portion of the foreign research reactor spent nuclear fuel at the Savannah River Site and vitrify the resulting high-level radioactive waste in the Defense Waste Processing Facility.

12. *Tritium Supply and Recycling Programmatic Environmental Impact Statement.* This Programmatic EIS evaluated the siting, construction and operation of tritium supply technology alternatives and the recycling facilities at five candidate DOE sites. The EIS also evaluated the use of a commercial reactor for producing tritium. Currently, DOE does not have the capability to produce tritium in the required amounts. The Savannah River Site in South Carolina, which will receive the aluminum-based foreign research reactor spent nuclear fuel, has been identified by DOE as the preferred site for an accelerator, should one be constructed, and the site for the upgrade and consolidation of existing recycling facilities.

The Final Programmatic EIS was completed and issued to the public in October 1995. The DOE Record of Decision was issued on December 12, 1995 (60 FR 63891) with a decision to implement the preferred alternatives.

13. *Stockpile Stewardship and Management Programmatic Environmental Impact Statement.* This EIS was originally a part of the Nuclear Weapons Complex Reconfiguration Programmatic Environmental Impact Statement. The Notice of Intent of this EIS was published on June 14, 1995 (60 FR 31291) after a prescoping workshop on May 19, 1995. This Programmatic EIS will examine activities required to maintain a high level of confidence in the safety and reliability of a reduced stockpile of nuclear weapons in the absence of underground nuclear testing. The Savannah River Site at Aiken, South Carolina, which houses the tritium loading/unloading and surveillance of tritium reservoirs, will receive the aluminum-based foreign research reactor spent nuclear fuel should the proposed action be implemented in the United States. This draft EIS is expected to be issued for public comment in February 1996.

1.6 Structure of this EIS

The remainder of this EIS is structured as follows:

- Chapter 2 presents the proposed action, describes management alternatives for implementation of the proposed action, alternative means of implementing each management alternative, and a No Action Alternative. Chapter 2 specifies the Preferred Alternative that has been developed by DOE and the Department of State.

- Chapter 3 characterizes the affected environments at potential ports of entry and at potential foreign research reactor spent nuclear fuel management locations.

- Chapter 4 addresses the policy considerations and the potential environmental impacts of each management alternative for implementation of the proposed action, alternative means of implementing each management alternative, and a No Action Alternative.

- Chapter 5 describes the international and domestic regulations governing radioactive materials that apply to DOE actions that might be taken under this EIS.

- Chapters 6, 7, and 8 contain primarily reference information, such as the List of Preparers, Agencies Consulted, and References, respectively.

The appendices to this document present details of the evaluations and analyses performed for this EIS.